

Prologue/Introduction:

OBJECTIVES:

1. Define and give examples of: **inferences, observations, predictions, and classification.**
2. Describe what is meant by **mass, volume and density.** How is each determined?
3. Determine the **density** of a material (ESRT P.1).
4. Define and be able to find **Percent Deviation.**
5. Describe the factors that affect the density of a material.
6. Describe how the density changes as things change phases (solid, liquid, and gas).
7. Define **Rate of Change** and be able to find it (ESRT P. 1)
8. Describe what is meant by the following relationships: **direct, indirect/inverse, cyclic** and be able to show what these graphs look like.
9. Describe what is meant by an **interface.**
10. Describe what is meant by **dynamic equilibrium**

THINGS TO REMEMBER:

1. Inference is a conclusion based on observations
2. The same uniform substance always has the same density
3. As pressure increases, density increases (inverse relationship)
4. As temperature increases, density decreases (inverse relationship)
5. Water expands as it freezes (increases in volume, decreases in density)
6. Most changes are cyclic
7. Water is most dense at 4°C (in its liquid phase)
8. Use the Earth Science Reference Tables (P. 1)

THINGS TO STUDY/CONSIDER:

Percent Error (*Percent Deviation*) = calculating how far away your measurement is from the accepted standard, calculated as a percentage. $\text{Percent Error} = \frac{\text{Accepted value} - \text{Measured value}}{\text{Accepted value}} \times 100$

Interpreting graphs: Graphs express relationships between the values shown on the graph. The “X” axis is the horizontal axis and the “Y” axis is the vertical axis.

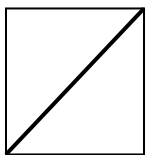
Common relationships expressed in graphs:

Graph (A) – as X increases, Y increases (**a direct relationship**)

Graph (B) – as X increases, Y decreases (sloped the opposite way, would be as X decreases, Y increases) (**an inverse relationship or indirect relationship**).

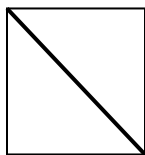
Graph (C) – as X increases, Y remains the same.

Graph (D) – as Y increases, X remains the same.



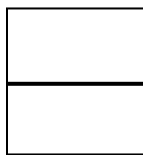
(A)

Direct



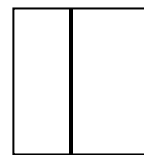
(B)

Inverse
(Indirect)



(C)

As x inc., y remains the same



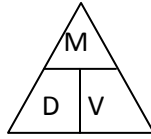
(D)

As y inc., x remains the same

Density = the mass of a cubic centimeter of a substance (g/cm^3) = mass /volume

****This image will help you in figuring out how to solve density problems:**

Simply cover up whichever value you need to calculate and the other two are shown in their proper placement, be it to multiply or to divide.



***Each substance has its own density (assuming temp and pressure are kept constant). The accepted density of aluminum is $2.7 \text{ g}/\text{cm}^3$

*****DENSITY DOES NOT CHANGE WITH THE SIZE OF THE SAMPLE!!!!**

The density of aluminum is $2.7 \text{ g}/\text{cm}^3$ whether you have a tiny piece of aluminum or a piece the size of the room.

*****The density of liquid water is $1.0 \text{ g}/\text{cm}^3$** ($1 \text{ cm}^3 = 1 \text{ mL}$). Anything less dense than this will **float** in water. Anything more dense than this will **sink** in water. **Ice floats in water because ice is less dense than water.**

Factors that affect density:

- **phase of matter.** Most substances are most dense in the solid state, less dense in the liquid state and least dense in the gaseous state. **The big exception to this is water.** Water is most dense in the liquid phase at 4°C .

- **temperature.** Generally, the higher the temperature, the lower the density.

- **pressure.** Generally, the higher the pressure, the greater the density.

Dynamic Equilibrium = when there is a state of balance because opposing forces are proceeding at equal rates. For example, when erosion and deposition in a stream are occurring at equal rates, there is no net gain or loss of material.

Cyclic changes are events that are continually repeated and are predictable.

Examples of cyclic changes:

- the monthly cycle of the phases of the Moon
- the yearly cycle of the seasons
- the daily cycle of sunrise and sunset
- the 11 year cycle of sunspot activity

Unit 1: Earth's Dimensions (Ch.1)

OBJECTIVES:

1. Describe the **shape** of the Earth (**actual and to scale**)
2. What is the **Lithosphere**? The **Atmosphere**? The **Hydrosphere**?
3. What are the properties of each of the **atmospheric layers**? (ESRT P. 14)
4. What is the relationship between latitude and altitude of the **Polaris**? Why?
5. What is a **model**? Why are they used in sciences?
6. How to construct a **topographic profile** from a **topographic map**.
7. Finding the **slope (gradient)** of locations on a topographic map. (ESRT P. 1)
8. How can you tell which way a river **flows** on a topographic map?
9. What is the **contour interval** of a contour map? What is the elevation of an ocean?
10. What are **latitude** and **longitude**? How do you find the coordinates for locations in New York State? (ESRT P. 3)
11. How do you find **distances** on a topographic map?
12. What are the **main elements** in each of the Earth's "spheres". (ESRT P. 11)
13. Describe the **Earth's shape** and give **evidence** for it.
14. Describe the **inferred** properties of the **Earth's interior** (ESRT P. 10)
15. Determine a location's **latitude** and **longitude** (ESRT P. 3, P. 5).
16. What are the **pointer stars** for the **Big Dipper** and **Little Dipper** for finding the **Polaris**?
17. Describe what is meant by: **isolines**, **contour lines**, **isotherms** and **isobars** and be able to draw them on a field map.
18. Determine **distances** and **elevations** on a field map.
19. Be able to determine **gradient** on a field map or a word problem (ESRT P. 1)

THINGS TO REMEMBER:

1. The best model of the Earth (to scale) is a sphere (or ball).
2. As depth increases, so do pressure and temperature (ESRT P. 10)
3. The altitude of the Polaris at a location is the latitude of that location (in the Northern Hemisphere).
4. Latitude lines run east-west, but measure degrees north or south of the Equator.
5. Longitude lines run north-south, but measure degrees east or west of the Prime Meridian
6. Longitude is based on observations of the sun.
7. Latitude is based on the observations of the Polaris.
8. The closer the lines are on a field map, the greater the gradient, or slope.
9. Use the Earth Science Reference Tables P. 1, 3, 10, 11 and 14

THINGS TO STUDY/CONSIDER:

Lithosphere - crust/solid portion of Earth's surface consists of Silicon and Oxygen.

Continental Crust – thick, made of granite, low density.

Oceanic Crust – thinner, made of basalt, high density.

Hydrosphere – Earth's water consists of Hydrogen and Oxygen

Atmosphere – layer of gas surrounding Earth consists of Nitrogen and Oxygen. Layers (Troposphere – where weather occurs, Stratosphere – Ozone Layer is located, Mesosphere, Thermosphere)

Oblate spheroid = the actual shape of the Earth. Earth is a **nearly perfect sphere** but is **slightly flattened** at the poles and **slightly bulging** at the equator. *** Pick the "perfect circle" diagram as best representing Earth's true shape! The bulging and flattening are very, very slight.

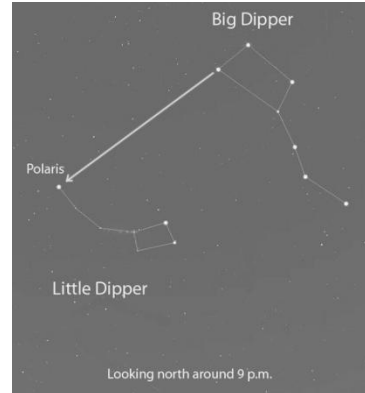
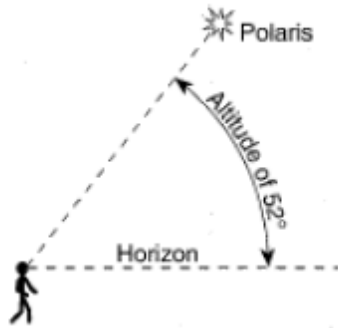
Evidence that the Earth is spherical:

- **photographs from space** show a spherical Earth
- **altitude of Polaris (North Star)** depends on the observer's latitude (northern hemisphere only). If you are at the North Pole, Polaris is directly overhead (90° angle above the horizon at 90° North latitude). If you are on the equator, Polaris is located on the horizon (0° above the horizon at 0° latitude).

ALTITUDE=LATITUDE

LATITUDE=ALTITUDE

Finding the North Star (Polaris)



- **observations of the way ships at sea seem to disappear and reappear:** When a ship is traveling away from the observer, toward the horizon, it disappears bottom first, top last. When a ship is approaching the observer from the horizon, it reappears top first, bottom last.

- **shape of the Earth's shadow on the Moon during a lunar eclipse:** The Earth casts a curved shadow on the Moon during a lunar eclipse.

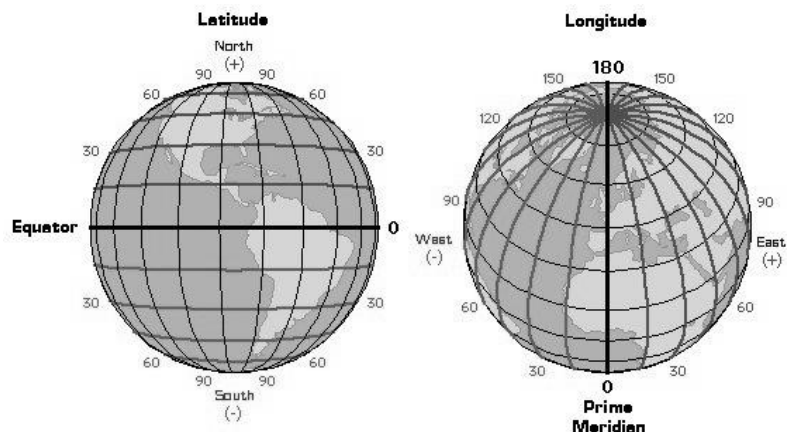
Astrolabe is an instrument used to find the angular altitude from the horizon to the position of a heavenly body. Sailors used astrolabes to figure out their latitude, since the altitude of Polaris above the horizon in degrees is equal to the latitude of the observer (northern hemisphere only).

Locating positions on Earth's surface:

Equator = an imaginary line that circles the Earth halfway between the North Pole and the South pole. This is the line of 0° latitude.

Latitude = distance north or south of the equator, measured in degrees. The equator lies at 0° latitude, the North Pole at 90° N latitude and the South Pole at 90° S latitude. A line of latitude is called a **parallel**.

Longitude = imaginary lines drawn around the Earth from the North Pole to the South Pole. A line of longitude is called a **meridian**.



Topographic maps show the shape of the Earth's surface by the use of **contour lines**.

Contour interval = the stated difference in elevation between contour lines on a topographic map.

***Where contour lines are close together, the slope of the land is steep.

***Where contour lines are far apart, the slope of the land is gentle.

Hachured lines are contour lines with little marks on them. They indicate areas of the land that go lower where one might expect the land to go higher. For example, hachured lines would indicate a crater at the top of a mountain.

*** **"V"s** in contour lines always point toward the higher elevations. Vees usually indicate the upstream direction of river flow. Rivers always flow from higher elevations to lower elevations.

A **benchmark** is a site whose elevation has been measured precisely. Benchmarks are indicated by a little "x" next to the number.

Know how to construct a Topographic Map Profile

Interactive Link

http://www.uwsp.edu/geo/faculty/ritter/geog101/textbook/manuals/instructor_manual/how_to/topographic_profile.html

Unit 2: Minerals and Rocks (Ch. 2)

OBJECTIVES:

1. Describe the **physical and chemical properties** of the minerals and what causes them (color, hardness, streak, luster, cleavage, fracture, crystal shape, magnetism, odor, acid reaction)
2. Describe how the three different rock types are **formed (origin)** and which rocks can form the different types
3. Using the ESRT, describe properties of the three types of rocks (ESRT P. 6 & 7)
4. Describe the properties of each type of rock and how you can tell what type you are looking at
5. Compare and contrast regional metamorphism and contact metamorphism
6. Describe what is meant by Moh's Hardness Scale

THINGS TO REMEMBER:

1. Minerals are naturally occurring substances that make up rocks.
2. The physical properties (hardness, streak, luster, cleavage/fracture, crystal shape, and density) are determined by the internal arrangement of the atoms
3. Rocks are classified by origin (Igneous, Sedimentary and Metamorphic)
4. Igneous rocks form by melting and solidification of another rock.
5. Cool fast → very small or no crystals (extrusive)
6. Cool slow → large crystals (intrusive)
7. Sedimentary Rocks are formed by compaction or precipitation from seas
8. Sedimentary rocks contain fossils and are formed in horizontal layers
9. Metamorphic rocks are formed by heat and pressure (metamorphism) of another rock
10. Metamorphic rocks show banding, foliations and may be distorted
11. Any rock type may form any other rock type
12. Use the Earth Science Reference Tables P. 6, 7, 11 and 16

THINGS TO STUDY/CONSIDER:

Rocks = the substances that make up the solid part of the Earth's crust; are usually a mixture of minerals.

Minerals = naturally occurring, inorganic crystalline substances. Each mineral is a different compound or single element. Minerals are identified by their **physical and chemical properties**.

Physical and Chemical Properties of Minerals

A. Physical Properties

- **Color** = the color of the whole piece. (Unreliable; many minerals are same color.)
- **Streak** = the color of the powdered mineral. Rub mineral on streak plate.
- **Cleavage and Fracture** = the way in which a sample of mineral splits or breaks.
Cleavage = breaks with parallel flat sides; Examples: halite – cubic cleavage)
Fracture = breaks irregularly (no parallel flat sides.) Examples: Quartz, pyrite, magnetite.
- **Hardness** = a mineral's ability to resist being scratched.
Soft (hardness 1 – 2.5) can be scratched with fingernail (mica, talc, gypsum)
Medium (hardness 3-5.5) cannot be scratched with fingernail and will not scratch glass (feldspar, fluorite)
Hard (hardness > 5.5) cannot be scratched with fingernail and will scratch glass (quartz, diamond)
- **Luster** = the way that the mineral "shines" or reflects light.
Metallic = shines like metal (galena, pyrite)
Nonmetallic = does not shine like a metal. Could be glassy, (quartz) dull (red hematite)

Chemical Properties = how a mineral reacts with other substances. For example, in the **acid test**, a few drops of HCl (hydrochloric acid) are put on a sample of the mineral. If there is a reaction, and **bubbles of carbon dioxide** (CO₂) form, then the mineral is probably **calcite**.

FORMATION OF ROCKS:

Rocks are classified according to the way that they formed. There are three major categories of the ways rocks can form:

Igneous Rocks form when melted (molten) rock cools down and becomes solid.

Sedimentary Rocks form when particles of weathered and eroded rocks become cemented together, from the remains of plants or animal, or from minerals which form in water.

Metamorphic Rocks form when other types of rocks become changed by heat, pressure, and/or chemically active fluids, **but have not been melted**. (If they do become melted, they become **igneous rocks** when they cool off again.

Clues to help ID Rocks:

Because **igneous rocks** have formed from molten magma or lava, they are composed of randomly arranged intergrown crystals. Rapid cooling, however can make the crystals too small to be visible. Igneous rocks are usually quite hard and dense, layering is rare. Gas bubbles (vesicles) sometimes give igneous rocks a frothy texture. "THIS IS AN IGNEOUS ROCK BECAUSE....:

1. Has random intergrown visible crystals
2. Has a glassy texture
3. Has vesicles



Most **sedimentary rocks** are composed of rounded fragments cemented in layers. In fine grained rocks the individual grains may be too small to be readily visible. A rock containing fossils is always a sedimentary rock. "THIS IS AN IGNEOUS ROCK BECAUSE....:

1. It is clastic
2. It is made of cemented particles
3. It has fossils
4. It has ripple marks



Most **metamorphic rocks**, like igneous rocks, are usually composed of intergrown crystals. And, like sedimentary rocks they often show layering in the form of banding or foliation. The layers may be bent or distorted. "THIS IS A METAMORPHIC ROCK BECAUSE....:

1. Shows mineral banding
2. Has distorted layers
3. Has visible mineral crystals in the form of foliation
4. Mica crystals are aligned causing the rock to sparkle



Study pages 6 and 7 in the Reference Tables to learn how igneous, sedimentary, and metamorphic rocks are classified.

Unit 3: Dynamic Crust - Earthquakes and Earthquake's Interior (Ch. 3)

OBJECTIVES:

1. Describe what the lithosphere is
2. Describe what is happening at plate boundaries and why (ESRT P. 5)
3. Describe what causes an earthquake
4. Describe what is meant by focus, epicenter, P-wave, S-wave, seismographs, and seismograms
5. Compare and contrast P-waves and S-waves (P. 11)
6. **Determine the distance from an epicenter** by p-wave and s-wave arrival times (ESRT P. 11)
7. **Determine the location of an epicenter** using arrival times from seismic stations (ESRT P. 11)
8. **Determine the origin time of an earthquake**
9. Compare and contrast Modified Mercalli Scale and Richter Scale
10. Describe the relationship between earthquakes and volcanoes
11. Describe what a tsunami is and what they may result in
12. Describe what is meant by the Shadow Zone
13. Describe the inferred properties of the Earth's interior (ESRT P. 10). Describe how scientists came up with this information.
14. Describe what is meant by Plate Tectonics and Continental Drift
15. Describe what is happening at **Convergent, Divergent and Transform boundaries** (ESRT P. 5) and give examples of each
16. Describe what forms at each of the three types of plate boundaries (ESRT P. 5)
17. Describe what is occurring in a **Convection Current** and relate it to Plate Tectonics
18. Describe what directions the continents have been moving over time (ESRT P. 9)
19. Compare and contrast the **Continental and Oceanic Crusts** (ESRT P. 10)
20. Use the ESRT P. 5, 9, 10, and 11

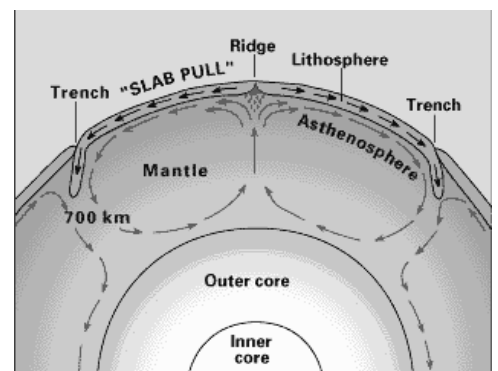
THINGS TO REMEMBER:

1. The crust is broken into lithospheric plates
2. P-Waves arrive first and travel through solids and liquids (compressional)
3. S-Waves arrive second and travel through solids only (shear)
4. The bigger the time between wave arrivals, the greater the distance to the epicenter
5. Three seismic stations are necessary to locate an epicenter
6. Convection currents in the mantle make the tectonic plates move
7. Continental Drift: Puzzle pieces, fossils, mountains, sea floor spreading
8. Mid-ocean Ridges - Divergent Boundary = new crust
9. Trenches - Convergent Boundary = old crust is recycled
10. Oceanic crust is basalt and more dense and thinner
11. Continental crust is granite and less dense and thicker
12. Use the Earth Science Reference Tables P. 5, 10 and 11

THINGS TO STUDY/CONSIDER:

Plate Tectonics is the theory that the earth's crust is composed of about a dozen "puzzle pieces" called **plates**. These plates shift, causing crustal changes such as volcanoes, earthquakes and mountain building along the edges of the plates. Edges are located along the west coasts of North and South America, along the Mid-Atlantic Ridge in the Atlantic Ocean, all around the edges of the Pacific Ocean, etc.

Plate Tectonics is driven by convection currents in the upper mantle. Hotter material moves upward causing divergent plate boundaries. Convergent boundaries occur at side of plate opposite the divergent boundary.



Convergent Plate Boundaries are places where two or more tectonic plates are crashing together. Example: The Pacific and North American plates are crashing into each other all along the west coast of North America.

Divergent Plate Boundaries are places where two or more tectonic plates are spreading apart.

The **Mid-Atlantic Ridge** is a divergent boundary.

Evidence of plate movement:

- matching 250 million year old rocks and fossils found along the west coast of Africa and the east coast of South America.
- edges of South America and Africa “match” in shape
- rocks get progressively older on each side of Mid-Atlantic Ridge as you travel east or west of the Ridge.
- earthquakes, mountain building and volcanoes along the edges of the plates show that there is movement and that heat is escaping.

Movement occurs along **faults** (breaks in Earth’s crust.)

Earthquakes happen when rocks get stressed by movement of tectonic plates, and finally break, causing movement along a fault.

- Most earthquakes happen in subduction zones (convergent boundaries) at plate edges. Pacific Ring of Fire (outlines Pacific Ocean) has most of world’s earthquakes and active volcanoes.
- Earthquakes produce P-waves and S-waves.
- P-waves travel faster and arrive first.
- S-waves travel slower and arrive after P-waves.
- Closer to the earthquake: P-wave and S-wave arrival times are closer together.
- Farther from the earthquake: more time elapses between the arrival of the P-waves and the S-waves.

A **focus** is the place underground where the actual movement along a fault occurred during an earthquake.

An **epicenter** is the location at Earth’s surface just above the focus.

Damage from earthquake depends upon:

- nearness to epicenter (closer, more damage)
- type of rocks underlying area (igneous, metamorphic are stronger → less shaking; sedimentary are weaker → more shaking.)
- whether **tsunami** results (giant ocean waves from earthquake in ocean)
- whether or not buildings have been built to withstand quakes.

Earthquake Disaster Preparation:

- Evacuation plan
- Conduct drills in the home; have a family meeting place
- first aid kit
- supply of water, food, battery-operated radio, flashlights, supply of cash, special items for infant, elderly, or disabled family members

Pangaea is the name scientists have given to the “supercontinent” that existed about 250 million years ago, when all of Earth’s major landmasses were joined together.

How to find the epicenter and the distance to the epicenter of an earthquake:

To find the distance of the station from the epicenter of a quake:

1. Turn to page 11 in the *Earth Science Reference Tables* to see the chart called “**Earthquake P-wave and S-wave Travel Time.**”

2. Note the arrival time of the P-waves and/or the S-waves. Find the difference between the two arrival times by subtracting the P-wave arrival time from the S-wave arrival time. Express the difference in minutes and seconds, such as 6:40 = 6 minutes, 40 seconds.

3. On a clean sheet of paper, mark the interval along the time travel scale on the vertical axis of the Time Travel Graph.

4. Slide the marks you made on the edge of the paper along the P- and S- curves of the Time Travel Graph until the marks are touching both curves.

5. Follow the marked edge of your paper down to the horizontal axis of the graph to find the distance from the epicenter. The distance is expressed in thousands of kilometers.

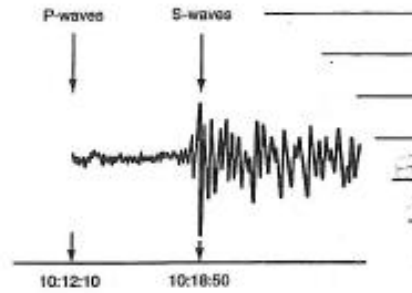
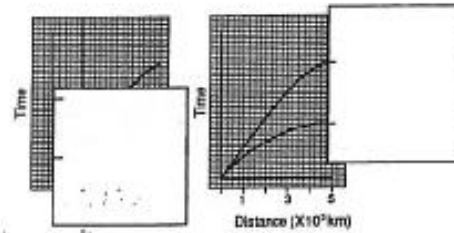


Figure 3-5A. A 6-minute, 40-second separation between P- and S-waves.



To find the location of the epicenter of an earthquake:

1. Perform the above procedures for three different station locations.
2. Using the calculated distance from the epicenter for **each** of the station locations, draw a circle around each of the stations, using the station as the center of the circle, and the distance of the station from the epicenter as the radius of the circle.
3. Find the place where **all three circles intersect**. This is the location of the epicenter of the quake.

To find the origin time of an Earthquake:

1. Time EQ wave arrived (P-wave) (ex: 12:55)
2. Given distance determine the travel time of p-wave (ex: 3000km = 5 min 40 sec travel time)
3. Subtract travel time from arrival time (ex: 12:55:00

$$\begin{array}{r} 12:55:00 \\ - \quad 5:40 \\ \hline 12:49:20 \end{array}$$
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Unit 4: Surface Processes and Landscapes (Ch. 4)

OBJECTIVES:

1. Describe what is occurring in **chemical weathering and physical weathering**
2. Describe the **type of climate** each occurs best in
3. Describe agents that cause each type of erosion
4. Describe the properties of the soil horizons
5. Compare and contrast transported soil and residual soil
6. Describe how **running water** and **glaciers** shape the land
7. Describe where the most **erosion/deposition** is occurring in a **meandering stream**
8. Describe the factors that affect how quickly deposition occurs and tell how each affects it
9. Describe what is meant by **horizontal sorting** and **vertical sorting** and tell where each is seen
10. Describe the bedrock **characteristics of the types of landscapes** (mountains, plateaus and plains)
11. Find locations of each landscape in NY State (ESRT P. 2)
12. Describe how an area's **climate affects the shape of the land**
13. Describe ways, in NY State, we can tell glaciers have been here before

THINGS TO REMEMBER:

1. Chemical weathering occurs best in warm, humid climates
2. Physical weathering occurs best in climates where temperature varies
3. Gravity is the force behind most erosional agents
4. Streams are the number one agent of erosion (V-shaped valleys)
5. Stream velocity depends on slope (gradient) and discharge (volume)
6. Water is fastest on the outside of a curve (most erosion) and slowest on the inside of the curve (most deposition)
7. Horizontal sorting: big, dense, round fall out first (rivers entering a body of water)
8. Vertical sorting: big, dense, and round land on bottom (dropping gravel in a pond)
9. Glaciers leave sediments unsorted and scratched (striated) and carve out a U-shaped valley
10. Arid (dry) Climates → steep slopes, no vegetation, thin soil
11. Moist (wet) Climates → rounded hills, vegetation, thicker soil
12. Physical Weathering - increases surface area to increase Chemical Weathering
13. Horizon A (top layer) has the most organic material (humus)
14. Mountains form by uplifting, folding and faulting
15. Dynamic equilibrium means a balance between 2 forces
16. Use Earth Science Reference Tables (P. 2, 3, and 6)

THINGS TO STUDY/CONSIDER

Physical weathering = changes in the size, shape and/or state of a rock, but **not** in chemical composition. No new substances are formed.

Agents of physical weathering:

- Frost action (repeated cycles of freezing and thawing; water expands when it freezes, breaks rocks)
- Plant roots
- Burrowing animals
- Abrasion (usually in streams)
- Wind

Chemical weathering = a change in the chemical composition of the rock caused by reactions with water, chemicals in the environment and with the atmosphere. New substances form as a result of chemical weathering.

Agents of chemical weathering:

- Water
- Oxidation (Rusting)
- Acid rain

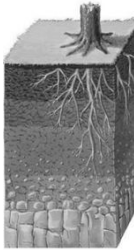
*** Whether physical or chemical weathering is most important in an area depends on the climate of the area.

Generally, chemical weathering is dominant in warm, moist climates, while cooler climates have more physical weathering than chemical weathering.

Soil is a mixture of weathered rock and organic components, (**humus**) such as dead roots, leaves, etc.

Soil horizons are the three distinct layers that form in a mature soil.

Soil horizons:



- **Horizon A** = the uppermost layer (at the surface). The A horizon is usually the layer richest in **humus** (organic matter). Water, air, burrowing animals, bacteria, plant roots are present. Some minerals have been dissolved (**leached**) by water in this layer.
- **Horizon B** = the layer just beneath Horizon A. Horizon B is poor in organic matter, but is enriched by materials leached from Horizon A.
- **Horizon C** = the layer below Horizon B and just above the bedrock. Horizon C is made up of bedrock in various stages of decomposition and weathering.

Types of soils:

- **Residual soil** is soil that remains on top of the bedrock upon which it formed. It has not been transported (moved).
- **Transported soil** is soil that has been moved by one or more agents of erosion. Transported soils have a different composition from that of the bedrock upon which they rest.

Agents of erosion:

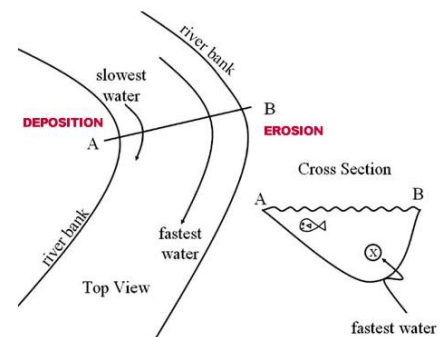
Liquid water erodes (transports sediments) by:

- **Solution** = particles that have dissolved in the water, forming a clear, transparent mixture. The particles in a solution are too small to be filtered out.
- **Suspension (colloids)** = tiny particles which have not dissolved, but do not settle out when the water is left standing. Suspended particles may be filtered out.
- **Flotation** = sediments of low density that are light enough to float.
- **Traction** = the largest, heaviest particles of sediment roll or bounce along the stream bed as they move.

Gravity is the most important agent of erosion. Gravity is the underlying mechanism for most types of erosion (sediment transport.)

Velocity of a stream:

- depends upon the gradient (change in elevation over distance) of the stream and the discharge (amount of water flowing) of the stream.
- determines the size of the particles that the stream can transport; there is a direct relationship between the velocity of the stream and the sizes of the particles able to be transported. The faster the flow of the stream, the larger the particles it will be capable of transporting.
- Rivers make V-shaped valleys
- Rivers deposit on the outside of meanders and erode on the inside of meanders.
- Rivers produce sorted deposits; larger, denser particles are deposited first as river slows down.



Erosion by wind:

- occurs mainly in arid (dry) areas; sand particles blowing around cause abrasion; wind transports these particles.

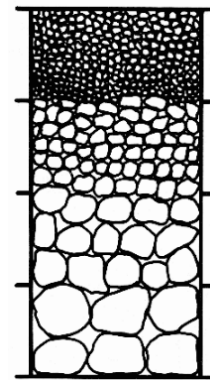
Erosion by ice:

A **glacier** is a large mass of moving ice.

- Glaciers make U-shaped valleys.
- Deposits are unsorted (all different sizes mixed together.); called glacial till. Glacial land formations include esker, drumlin, cirque.
- **Outwash plain** is sorted deposits produced by glacial meltwaters forming rivers. North shore of L.I. is rocky because glaciers stopped here; outwash rivers carried finer material (sand) to south shore.
- **Ice ages** periods of widespread continental glaciation.
- There have been four ice ages in the NY area in the past million years (Pleistocene)
- Glaciers formed Long Island (between 20,000 – 12,000 years ago.)
- **Striations** are parallel scratches in bedrock caused by abrasion as the ice carried particles over the bedrock.

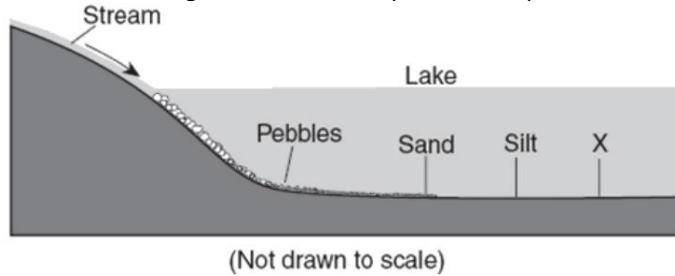
Rates of Deposition (how fast material is deposited) are affected by:

- Particle size (larger settle more quickly)
- Particle shape (flatter settle more slowly)
- Particle density (denser settle more quickly)
- the faster the water, the fewer particles that will settle\



Vertical sorting: Particles are deposited in layers, from largest in the bottommost layer to the smallest in the topmost layer. (Example: bunch of stuff dumped into a lake all at once settles this way.)

Horizontal sorting: As a river slows, particles drop out from largest to smallest along the riverbed.



Gradient: This is the change in height over distance traveled. Generally, erosion proceeds faster in areas of high gradient; deposition takes place in areas of low or no gradient.

Dynamic equilibrium: This is when the rate of erosion is equal to the rate of deposition, so there is no net change in the level of the sediments.

Oceans and coastal processes:

- **Oceans** cover nearly 71% of Earth’s surface, to an average depth of 4 kilometers (3 miles).
- **Waves near the shore** and **longshore currents** (currents parallel to shoreline) change the land at the edges of the oceans.
- ***Waves out in the deep ocean do **not** carry water along; the wave of energy simple passes through the water that is there.

Landscape Development:

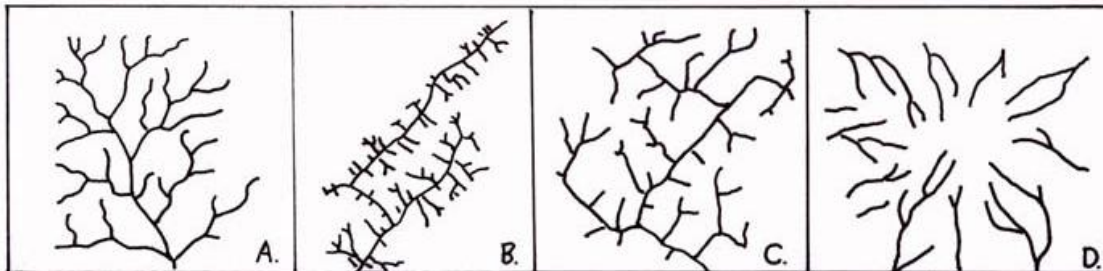
* A **landscape** is a region on the Earth's surface in which the physical features of the region are related by a common origin. Examples of landscapes include mountains, plateaus, plains.

Mountain landscapes: greatest changes in elevation; steep gradients; fast-flowing streams; commonly underlain by metamorphic rock, igneous rock, or folded sedimentary rock. (Rocky Mountains)

Plateau landscapes: are relatively "flat," but have greater elevations than plains; are the product of uplift; have deep valleys; commonly underlain by horizontal sedimentary rock layers. (Colorado Plateau, Allegheny Plateau.)

Plains landscapes: are relatively "flat" and at low elevations; gentle slopes; low gradients; underlain by flat layers of sedimentary rock; have meandering streams with wide floodplains.

Stream drainage patterns are determined largely by the type of bedrock underlying an area.



- **(A) Dendritic drainage** has a tree-like, branching pattern. Dendritic drainage patterns form where bedrock is made of flat-lying layers of uniform composition. There are no specific areas of weakness in the rocks.
- **(B) Trellis drainage** is a rectangular pattern of streams that usually forms in an area where rocks have been folded. The incompetent layers erode away to form parallel valleys; the more competent layers form parallel ridges.
- **(C) Rectangular drainage** is when streams flow and join at right angles. It forms when there are specific areas of weaker and more resistant rock layers that promote the formation of this pattern.
- **(D) Radial drainage** is a pattern of streams radiating from a central area, such as down the sides of a volcano or a rounded hill. There is little difference in rock competence (weakness/strength) in the area.
- **Annular drainage** resembles radial, but is a pattern of streams in concentric circles. It forms on mountains where there is a great difference in the competence of the exposed rock layers.

Landscape maturity depends on the portion of the land that has been worn down to **base level** (lowest possible elevations in the area).

Maturities of landscapes:

- **Youthful landscapes** have high elevations, steep hill slopes, high gradients and narrow, fast-running streams. There may be waterfalls and rapids. Soils are immature. Rivers are downcutting their channels.
- **Mature landscapes** are more rounded and have lower elevations with gradual hill slopes. Stream valleys are broad, rivers have meanders and have developed floodplains. Streams have begun to deposit some of their sediments.
- **Old age landscapes** have had most of the land eroded down to near base level. The area is mostly flat, but there may be a few hills. Streams have a very low gradient, wide floodplains and many meanders. Soils are thick and well-developed. Streams are depositing much of their sediments.
- **Rejuvenated landscapes** form when an existing landscape is uplifted, causing slopes to increase in gradient and causing streams to begin downcutting again.

Unit 5: Earth's History (Ch. 5)

OBJECTIVES:

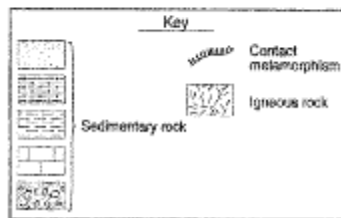
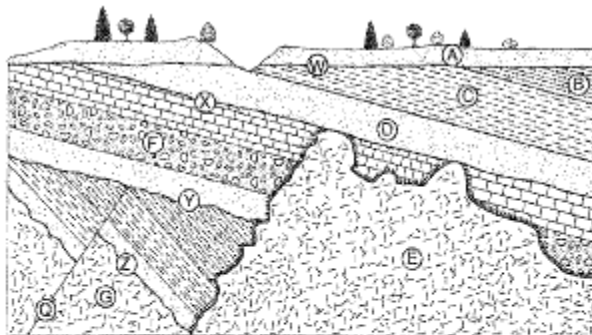
1. Describe the difference between **absolute age** and **relative age** and tell how each can be found
2. Describe what is meant by radioactive dating and how to do it
3. Describe what is meant by **half-life** and what it is used for
4. Describe what the **Law of Superposition** is
5. Describe what an **unconformity** is and what it means
6. Describe what an **index fossil** is and what they are used for
7. Describe the major life forms in each geologic time period
8. Describe what is meant by organic evolution

THINGS TO REMEMBER:

1. The half-life of an element can not be changed by heat or pressure
2. Index fossils are good time markers (geologically widespread over a short time)
3. Law of Superposition = oldest on bottom, youngest on top (undisturbed layers)
4. Intrusions and faults are younger than the rock layers they cut through
5. Unconformity = period of erosion where part of the rock record is missing
6. U-238 dates very old rocks
7. C-14 dates very young rocks and fossils
8. Use the Earth Science Reference Tables (P. 1, 2, 3, 8, and 9)

THINGS TO STUDY/CONSIDER:

Principle



Earth history compressed into one year

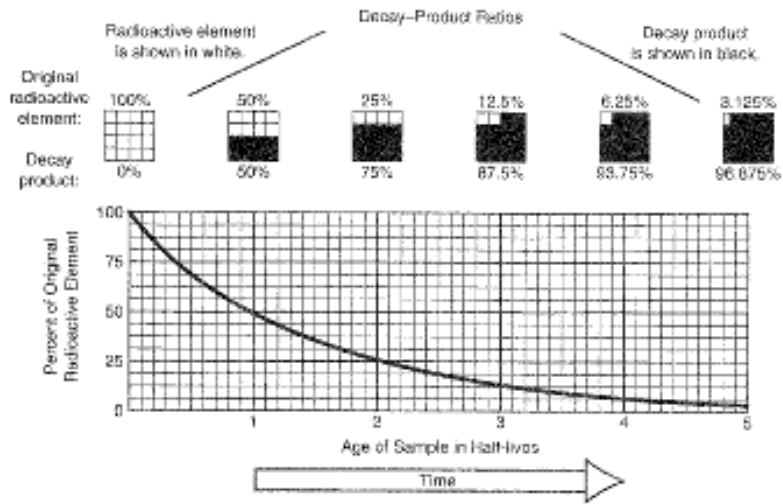
Jan. 1	Beginning of Earth
Feb. 21	Life evolved
Oct. 25	Complex organisms w/shells
Dec. 7	Reptiles appeared
Dec. 25	Dinosaurs went extinct
Dec. 31, 11pm	Homo sapiens appeared
Dec. 31, 11:58:45 pm	Last glacial ice age ended

Radioactive Dating utilizes the known radioactive decay rates of certain isotopes of elements to get the **absolute age** of an object, measured in years.

HALF-LIFE

A **half-life** is the amount of time required for **half** the amount of a given sample of a radioactive element to decay into its decay product.

***** IT DOES NOT MATTER HOW BIG THE SAMPLE IS! During a half-life, HALF the amount of the radioactive sample will decay into its more stable product. NOTHING CAN CHANGE THE AMOUNT OF TIME IT TAKES FOR A HALF LIFE FOR A CERTAIN RADIOACTIVE ISOTOPE TO DECAY TO ITS STABLE PRODUCT! The length of time it takes for a half-life to pass depends upon which radioactive element it is. (See p. 1 of Reference Tables)



In an “undisturbed” sample:

*** After ONE half-life, half of the original sample of radioactive isotope will be left.

After TWO half-lives, one-fourth of the original radioactive sample will be left.

After THREE half-lives, one-eighth of the original radioactive sample will be left.

After FOUR half-lives, one-sixteenth of the original radioactive sample will be left

After FIVE half-lives, 1/32 of the original radioactive sample will be left.

.....and so on

At each step, a proportionate amount of stable decay product will also be present in the sample.

***Radioactive isotopes are “good” for dating time periods of up to six or seven half-lives. After this amount of time, there is little to none of the original radioactive isotope left in the sample. This is why C¹⁴ can only date a sample to 50,000 years old and no older. Other, more long-lasting isotopes would have to be used for dating something older than that.

Unit 6: Meteorology and Atmospheric Energy (Ch. 6 and 7)

OBJECTIVES:

1. How does the temperature vary with the **intensity and duration of insolation**?
2. What are the **Wet Bulb Temperature** and **Dry Bulb Temperature**?
3. What is the **Dew Point Temperature**? How is this determined? (**ESRT P. 12**)
4. What is the **Relative Humidity**? How is this determined? (**ESRT P. 12**)
5. What is a Sling Psychrometer?
6. How do you convert temperatures in degrees Fahrenheit to Celsius and vice versa? (**ESRT P. 13**)
7. What are isotherms?
8. What is the air pressure? What is it measured by?
9. What does air pressure have to do with winds?
10. What controls the speed of winds?
11. What is determined by a wind vane? An anemometer?
12. What must happen to warm, moist air to make a **cloud form**?
13. How does elevation affect air pressure?
14. What causes a **Sea Breeze**? A **Land Breeze**?
15. How does an **air mass** change as it passes over a mountain range? How is the air on the windward side compared to the leeward side?
16. What are the processes involved in the **Water Cycle**?
17. What is transpiration?
18. What is the **specific heat of water**? How does this affect the water or areas around it?
19. How is heat transferred through the following: **Convection, Conduction and Radiation**?
20. Why does the wind appear to blow in wind belts? (**ESRT P. 14**)
21. What are Zones of Convergence? Zones of Divergence?
22. What are the different types of air masses and the type of air they bring (mT, cT, mP, and cP)?
23. How does the air move around a **Low Pressure Area (Cyclone)**? An **Anticyclone (High Pressure Area)**?
24. What is happening at each of the four types of **fronts**? What are their symbols? (**ESRT P. 13**)
25. What is the information given on a **Station Model**? (**ESRT P. 13**)
26. What is the typical Storm Track in NY State? Why?
27. What conditions would hurricanes form in? Tornadoes?

THINGS TO REMEMBER:

1. Air moves CCW inward around a LOW (Zone of Convergence)
2. Air moves CW outward around a HIGH (Zone of Divergence)
3. Good absorber = good radiator (black and rough)
4. As air temperature increases, pressure decreases (inverse relationship)
5. As humidity increases, pressure decreases (inverse relationship)
6. As elevation increases, pressure decreases
7. HIGHS are cool and dry
8. LOWS are warmer and moister (storms)
9. Wind speed is controlled by pressure gradient (fastest = closest lines)
10. Winds always blow from HIGH to LOW pressure areas
11. Winds are named by where they come from
12. The closer the air temperature (dry bulb) is to the DPT, the greater the chance of precipitation
13. Weather moves from West to East in the US (or toward NE)
14. Cold fronts move faster than warm fronts
15. Air cools as it rises due to expansion
16. Air warms as it sinks due to compression
17. Use the Earth Science Reference Tables (P. 12 & 13)

THINGS TO STUDY/CONSIDER:

Atmospheric Pressure is a measure of the force exerted by the atmosphere. Changes in atmospheric pressure are caused by changes in the density of the air.

- *** **Warmer air** is less dense → **lower atmospheric pressure**
- *** **Cooler air** is more dense → **higher atmospheric pressure**
- *** **Wetter (more humid) air** is less dense → **lower atmospheric pressure**
- *** **Dryer (less humid air)** is more dense → **higher atmospheric pressure**

- **Relative Humidity** is a measure of the percentage of moisture saturation of the air. Relative humidity is measured with an instrument called a **psychrometer**, which tells us the **wet bulb and dry bulb temperatures**. We then use the **Relative Humidity Chart** in the *Reference Tables* to calculate the relative humidity. Relative humidity tells us how much moisture the air *is currently holding* as compared to how much moisture the air *could hold at that temperature*. A relative humidity of 80% would mean that the air is holding 80% as much moisture as it could hold at that temperature.
 - *** **Air temperature** determines the air's capacity to hold moisture.
 - *** **Warmer air** can hold more moisture.
 - *** **Cooler air** can hold less moisture.

A relative humidity of 100% means that the air is holding the maximum amount possible at a particular combination of air temperature and air pressure.

Absolute Humidity is not a weather factor! **Absolute Humidity** is the percentage of the entire atmosphere that is composed of water vapor. ***This is always less than 1%***

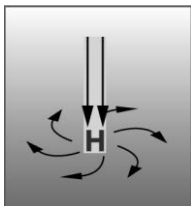
Formation of clouds

1. Warm air rises
2. As the air rises it expands
3. Expansion cause the air to cool
4. Air cools to the dew point
5. Once at dew point in condenses and forms the cloud

Wind direction tells you the direction the wind ***is coming from***.

The **Coriolis Effect** causes the planetary wind belts to curve, generally to the right in the northern hemisphere and to the left in the southern hemisphere. The Coriolis Effect is a result of the Earth's rotation; the atmosphere lags as the Earth rotates.

High Pressure = cool, dry air

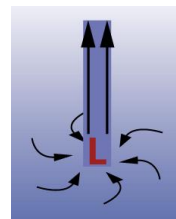


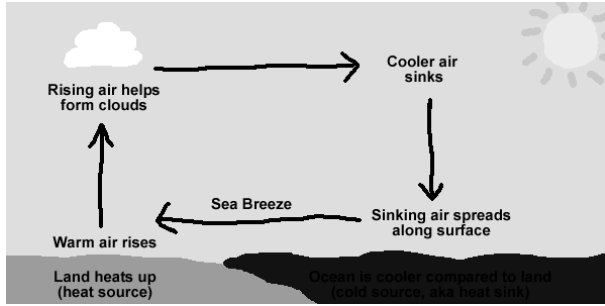
Air moves out and clockwise

Low Pressure – warm, moist air

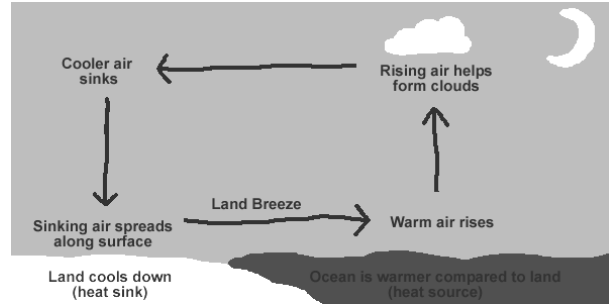


Air moves in and counterclockwise





Sea Breeze



Land Breeze

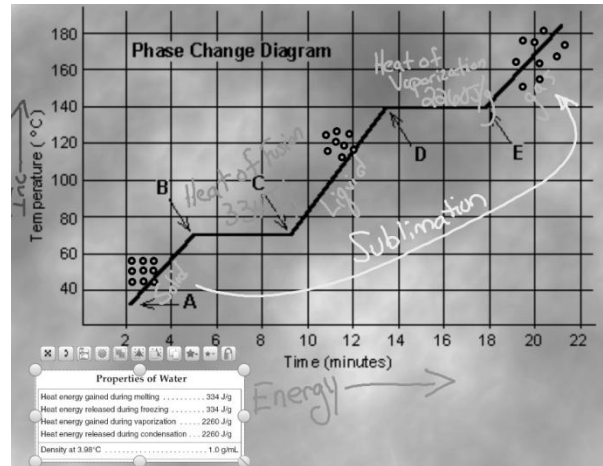
Measuring Kinetic Energy

• A **thermometer** measures **temperature**, which is the average kinetic energy of the molecules (particles) in a substance or object.

• **Absolute Zero** (0° Kelvin, -273° Celsius) is the point at which there is a total absence of heat. At absolute zero, there is no molecular movement at all. There is no temperature "colder" or lower than absolute zero!!!!

Changes in Phase:

- occur when enough heat energy is added or subtracted.
- **Melting** is a phase change from solid to liquid.
- **Freezing** is a phase change from liquid to solid.
- **Evaporation** is a phase change from liquid to gas.
- **Condensation** is a phase change from gas to liquid.
- **Sublimation** is a change of state from a gas directly to a solid or from a solid directly to a gas, without passing through the liquid phase.

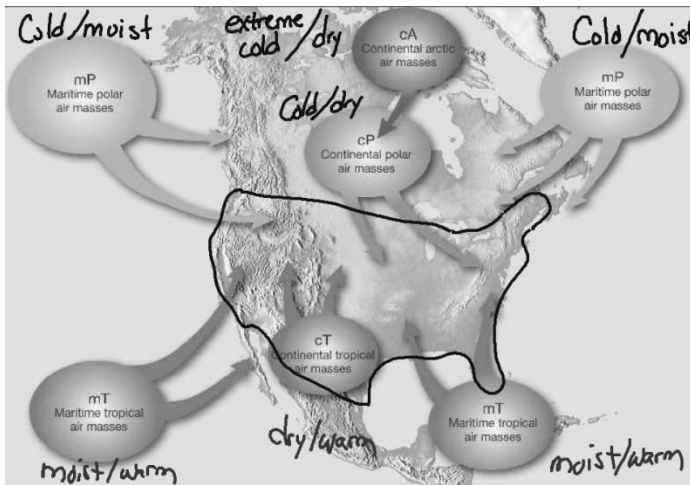


****** THERE IS NO TEMPERATURE CHANGE DURING A PHASE CHANGE!!!**

O₃ (ozone) absorbs ultraviolet (UV) radiation.

CO₂ (carbon dioxide) absorbs infrared radiation (heat) and causes global warming.

Fronts



Air Masses

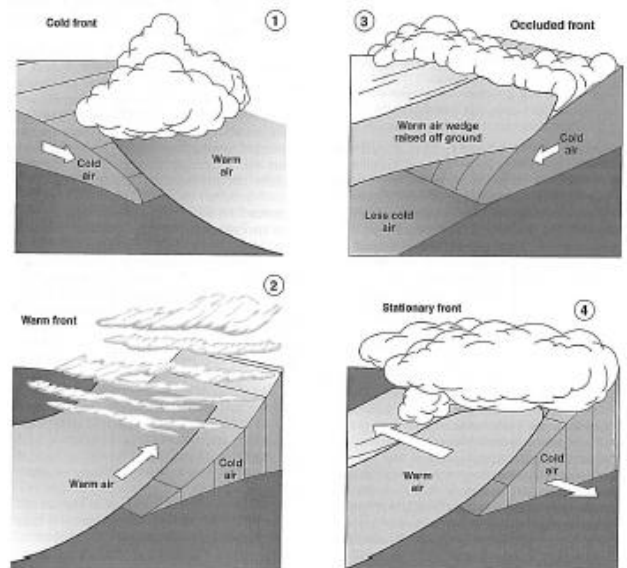


Figure 7-12. Four types of weather fronts.

Unit 7: Water Cycle and Climate (Ch. 8)

OBJECTIVES:

1. Earth has been continuously recycling water. This is done by the **Water (Hydrologic) Cycle**
2. Explain what is happening in the processes of precipitation, evaporation, transpiration, runoff, infiltration
3. Explain how capillarity influences the above processes
4. Explain how climate, slope, soil, rock type, vegetation, land use, and saturation affect the amount of precipitation infiltrating the ground
5. Explain how **porosity, permeability** and water retention affect runoff and infiltration
6. Explain how the intensity of insolation affects the climate of an area
7. Describe how color, texture, transparence, state of matter and specific heat affect the heating of materials
8. Heating within the atmosphere occurs through conduction, convection and radiation
9. Explain how the following **affect the climate** of an area: **latitude, large bodies of water, ocean currents, prevailing winds, vegetative cover, elevation and mountain ranges**
10. Explain how El Nino and volcanic eruptions may affect the weather patterns

THINGS TO REMEMBER:

1. Summer Solstice is June 21st (sun is directly overhead at Tropic of Cancer)
2. Winter Solstice is December 21st (sun is directly overhead at Tropic of Capricorn)
3. Equinoxes are March 21 and September 23rd (overhead at equator)
4. Equator gets most direct rays most of the year
5. Energy moves from source to sink
6. Hottest time of the year is July/August
7. Hottest time of day is 2-3 PM
8. Porosity does not depend on particle size
9. As particle size increases, permeability increases and capillarity decreases
10. Capillarity increases as particle size decreases
11. Potential Evapotranspiration depends on temperature
12. Increases in latitude and altitude have the same effect on climate (--> cooler)
13. Vertical rays can only happen between 23.5 N and 23.5 S
14. Bodies of water moderate temperature (smaller temperature range)
15. Know this table:

Date	Location	Sunrise	Sunset
June 21	Tropic of Cancer (23.5°N)	NE	NW
September 23	Equator (0°)	East	West
December 21	Tropic of Capricorn (23.5°S)	SE	SW
March 21	Equator (0°)	East	West

16. The sun appears to move at a rate of 15°/hour
17. Use the Earth Science Reference Tables (P. 1, 4, 14, and 15)

THINGS TO STUDY/CONSIDER:
Water Cycle

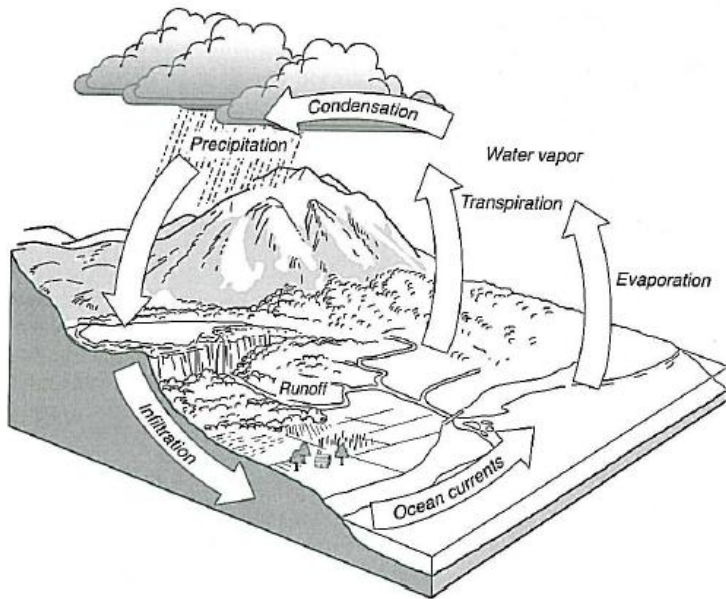


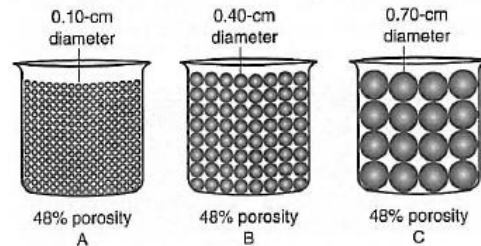
Figure 8-2. Water circulates between the atmosphere, the land, and the oceans in a never-ending series of changes. Changes shown in the hydrologic cycle include precipitation, infiltration, runoff, evaporation, transpiration, convection (movement via the wind), and condensation.

Potential Evapotranspiration (E_p) = temperature; higher temp = higher E_p

Porosity is unaffected by particle size.

Larger particles are more permeable; they let water pass through more quickly (faster rate, less time.)

Capillarity (water retention) is most effective between smaller particles



Methods of transfer of heat energy:

Radiation is energy transfer by means of electromagnetic waves. It is the only method of heat transfer that can travel through empty space (a vacuum,) but it is not limited to traveling through empty space.

Conduction is energy transfer through solids, from molecule to molecule. Metals are particularly good conductors of heat energy.

Convection is the way energy travels through fluids (liquids and gases). The warmer (more energetic) molecules spread apart, becoming less dense and rising. The cooler molecules (which are closer together and therefore more dense) move to take the place of the molecules that have risen. This sets up a circular pattern of warmer molecules rising and cooler molecules falling. Uneven heating of the Earth's atmosphere and oceans causes winds and ocean currents to form.

Electromagnetic Energy is the form of energy we receive from the Sun. It is energy that travels in the form of *electromagnetic waves*, usually by the process of radiation.

Electromagnetic Waves vary in *wavelength* and *frequency*.

The **Electromagnetic Spectrum** is composed of all the wavelengths of e.m. energy from the longest (radio waves) to the shortest (gamma rays). (See the Reference Tables.)

Visible Light = the part of the e.m. spectrum that can be perceived by our eyes. Our eyes perceive the different wavelengths of the visible spectrum as different colors. The visible portion of the e.m. spectrum makes up only a tiny part of the entire e.m. spectrum.

Reflection = bounced off, as light bounces off a mirror.

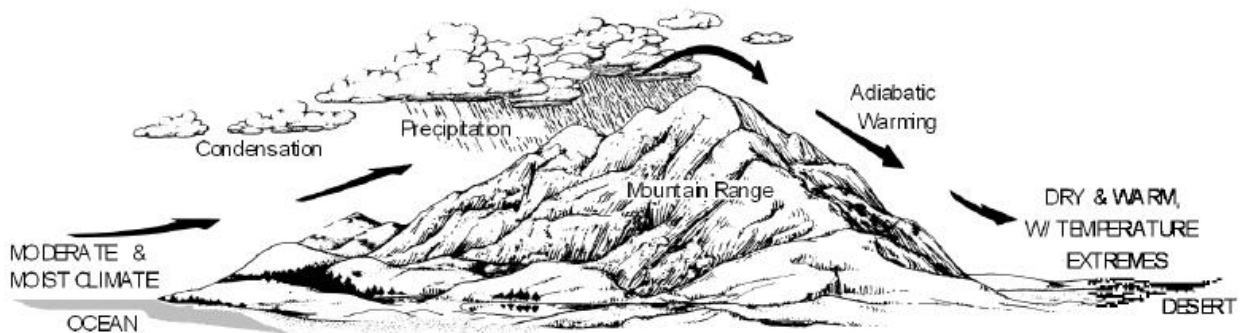
Refraction = scattered, bent, slowed down, shifted to lower wavelengths, as happens when light enters the thicker portions of the atmosphere nearer to Earth's surface. Refraction of sunlight causes the sky to appear "blue."

Absorption = taken in – as when the sand on the beach gets hot on a summer day. The energy that is absorbed is usually **reradiated** as electromagnetic energy of longer wavelengths (infrared,) if the object that absorbed the radiation becomes warmer than its surroundings.

**** A good absorber is a good re-radiator.

Factors affecting Climate

Orographic Lifting



Unit 8: Astronomy (Ch. 9 and 10)

OBJECTIVES:

1. Use **eccentricity** in context and know how to determine it.
2. Understand the **relationships** between: the planets' distance from the Sun, gravitational force, period of revolution, and speed of revolution
3. Determine the **changing length of a shadow** based on the motion of the Sun
4. Describe the relationship between **gravity and inertia** and its effects on the orbits of planets or satellites
5. Describe what **causes each of the motions**: daily cycle, yearly cycle, seasons, moon phases, eclipses, and tides
6. Describe how the force of gravity changes as the masses and distance between two objects changes
7. Describe the paths of the planets as an ellipse around the Sun with the Sun as one focus
8. Earth is orbited by one moon and many artificial satellites
- 9. Earth rotates at 15 °/hour**
10. The Earth's rotation is the basis for time measurements
11. Describe the **Foucault Pendulum**, the **Coriolis Effect** as evidence for the Earth's rotation.
12. Describe the evidence for the Earth's rotation and revolution.
13. Describe the changes in position of the Earth relative to the Sun throughout the year and how this affects us on Earth
14. Describe how the **apparent path of the Sun** changes throughout the year
15. Describe how the oceans are affected by the moon
16. Describe the **Geocentric Model** and the **Heliocentric Model**
17. Develop a scale model of a planet and/or distances
18. Describe the current theories on the **origin of the universe** and evidence for it (cosmic background radiation and **red-shift**)
19. Describe the **changes stars go through in their life cycle** and how each stage is different (H-R Diagram)
20. Describe how the planets came about and the general characteristics of them
21. Define asteroids, comets and meteors

THINGS TO REMEMBER:

1. The universe began as a big explosion - "The Big Bang Theory"
2. Our solar system is located in one of the outer arms of the Milky Way Galaxy
3. The Earth rotates from W to E (CCW as you look down at North Pole) every 24 hours
4. Earth Revolves CCW around the Sun in 365.25 days (=> Leap year)
5. All celestial objects appear to rise in the east and set in the west moving around the Polaris
6. We see the moon in phases because it is revolving around the Earth (remember: half is always lit up)
7. Some planets show retrograde (backwards) motion because Earth passes them in space
8. The lower the altitude of the Sun, the longer the shadow
9. Foucault's Pendulum and the Coriolis Effect prove that the Earth rotates on its axis
10. Earth is closest to the Sun in the winter (perihelion) but we have less direct rays
11. Earth is farthest from the Sun in the Summer (aphelion) but we have more direct rays
12. The closer a planet is to the Sun, the shorter its period of revolution
13. Use the Earth Science Reference Tables (P. 1 & 15)

THINGS TO STUDY/CONSIDER:

Spring Equinox ~ March 21 Fall Equinox ~ September 21

(Equinox = equal day and night)

Summer Solstice ~ June 21 (longest day of year in Northern hemisphere)

Winter Solstice ~ December 21 (shortest day of year in Northern hemisphere)

***The equator has about 12 hours of daytime every day of the year.

Geocentric Model:

- is **Earth-centered**; Earth is at the center of the universe; the Sun, the planets and all the stars circle the Earth.

- proposed by **Ptolemy** about 2000 years ago.
- the stars, the Sun and all the planets are located on transparent “spheres” that revolve around the Earth from east to west once each day.

Observations explained by the geocentric model:

- the daily apparent motions of the Moon, the Sun and the stars

Observations NOT explained by the geocentric model:

- cannot predict exactly the future motions of the planets.
- cannot explain the change in direction of a pendulum’s swing (**Foucault pendulum**).
- cannot explain the **Coriolis Effect** – the curving of the paths of projectiles, winds and ocean currents.

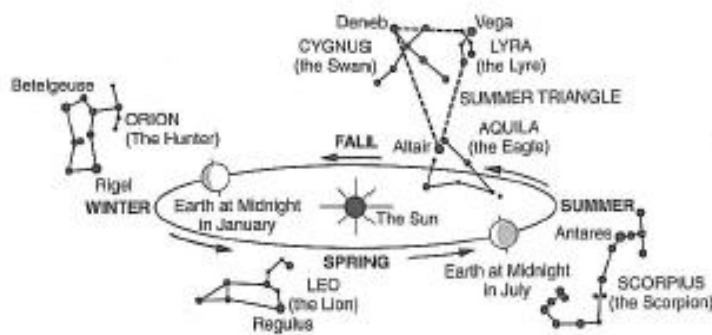


Figure 9-5. As Earth revolves around the sun, the night side faces toward different constellations. Only those constellations that face Earth's night side are visible to us.

Heliocentric Model:

- is **Sun-centered**; The Sun is located at the center of the Solar System and does not move. The planets circle around the Sun.

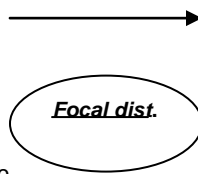
- proposed by **Copernicus** in 1543; added to and modified by **Tycho Brahe** and **Johannes Kepler**.

Observations explained by the heliocentric model:

- the apparent daily motion from east to west of all celestial objects around the Earth (is due to the **rotation** of Earth on its axis, completed once every 24 hours).
- explains the eastward motion of the Sun through the stars.
- can predict accurately the motions of the other planets; states that each planet travels in its own orbit around the Sun.
- explains the changing **apparent diameter** and the changing **apparent brightness** of the Sun and the planets; as Earth orbits around the Sun, its distance from the Sun and from each of the planets varies. For example, the Sun *looks larger* in the *winter* because Earth is *closer* to the Sun in winter than at any other time of the year.
- explains the motions of the **Foucault pendulum** and the existence of the **Coriolis effect**. Both are caused by the rotational movement of the Earth.
- Earth rotates on its axis from West to East (counterclockwise) in 24 hrs or **15°/hr**.
- Earth revolves around the sun counterclockwise in 365 ¼ days or 1 year.

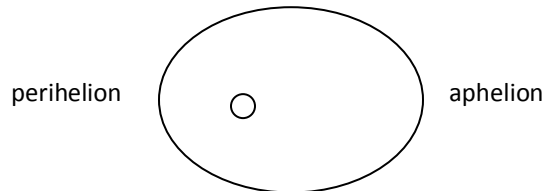
. Kepler worked out a mathematical formula to calculate how flattened any elliptical orbit is. He called this flattening the orbit's **eccentricity**:

$$\text{Eccentricity} = \frac{\text{distance between foci}}{\text{length of major axis}}$$



length of major axis (from circumference to circumference through the focal distance)

The **average distance of a planet from the Sun** is equal to one-half the length of the major axis of its orbit.

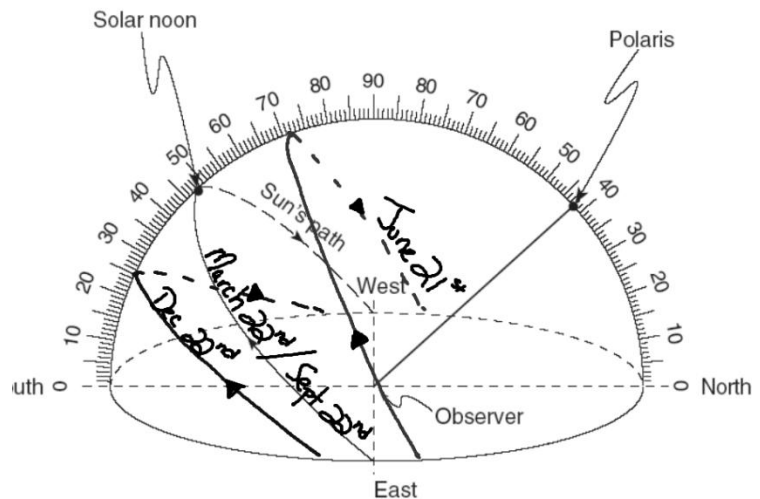


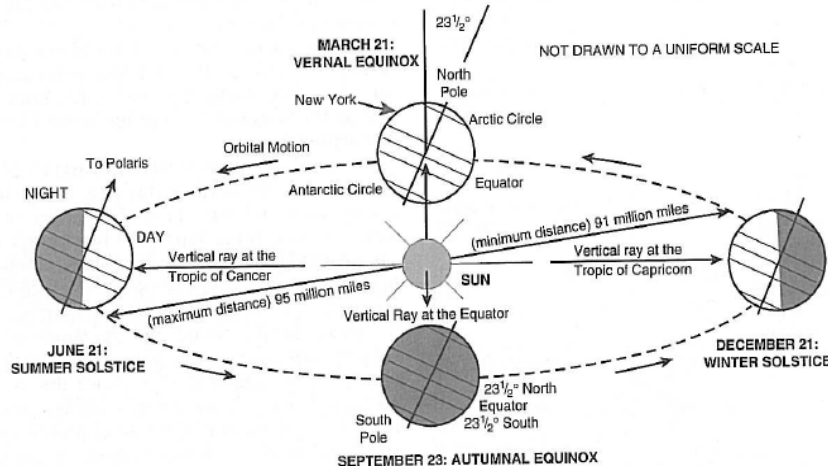
perihelion = when the planet is nearest to the Sun (early January for Earth) it moves at a greater velocity.

aphelion = when the planet is farthest from the Sun (early July for Earth)

Seasons:

- Are the result of the Earth's location in its path around the Sun, the tilt of the Earth's **axis** (23.5°) and the **angle of insolation** (angle at which the Sun's rays are striking the ground.) The **angle of insolation** is greatest for the northern hemisphere in June, lowest for the northern hemisphere in December.
- Seasons are reversed in the northern and southern hemispheres. That is, when the northern hemisphere is having winter, the southern hemisphere is having summer.
- At the **autumnal equinox** (about Sept. 21) and the **vernal equinox** (about March 21,) daylight lasts for about 12 hours all over the world.
- The greatest number of hours of daylight in the northern hemisphere occurs at the **summer solstice** around June 21. For the NY area, there is about 15 hours of daylight on this day.
- The shortest number of hours of daylight in the northern hemisphere occurs at the **winter solstice** around December 21. For the NY area, there is about 9 hours of daylight on this day.
- The number of hours of daylight varies cyclically and therefore predictably throughout the year.
- The lower the altitude of the sun the longer the shadow.





Phases of the Moon:

■ **Phases** = the cyclical changes in the apparent shape of the lighted portion of the Moon. One half of the Moon is always facing the Sun, but the lighted portion of the Moon is NOT always facing the Earth.

■ The only part of the Moon that we can see is the portion that is both lighted by the Sun *and is facing towards the Earth*.

- A **solar eclipse** occurs when there is a **new moon phase** (the entire unlighted half of the Moon is facing the Earth and the Moon is passing in between the Sun and the Earth.) The Moon appears to block out the Sun as the Moon passes between the Sun and the Earth. This is rare, because all three bodies do not line up exactly very often.
- A **lunar eclipse** occurs when the Earth passes in between the Sun and the **full moon phase**. The Earth's shadow blocks out the Moon, causing the full moon to disappear and reappear.
- It takes about 29.5 days for the Moon to complete one orbit around the earth. That is why it takes about 29.5 days for the Moon to complete its cycle of phases.

New Moon	Waxing Crescent	1st Qtr	Waxing Gibbous	Full Moon	Waning Gibbous	Last Qtr	Waning Crescent

The right side of the Moon appears first (waxing phases). The left side of the Moon vanishes last (waning phases)

Tides

Spring Tide

Highest Tides – occur when the Moon is in the New Moon position working with the sun to draw the Earth's water

Neap Tide

Lowest Tides – occur when the Moon is in the Qtr. Phases working against the sun to draw the Earth's water

Sun

Source of sun's energy is Nuclear Fusion